Synchrotron Topographic Observation of Screw Dislocation Termination in SiC

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Beamline(s): **X19C**

Introduction: The most harmful defects in silicon carbide (SiC) are the so-called "micropipes," which are hollow-core screw dislocations with the Burgers vectors being multiples of the lattice constant *c*. The other commonly observed defect is the elementary screw dislocations with the Burgers vector equal to *c*. Although some progresses in decreasing the micropipe density have been achieved, formation of high-density elementary screw dislocations during SiC growth is still a persistent problem. In our previous work, we have demonstrated that one of the formation mechanisms of micropipes and elementary screw dislocations is that these dislocations can be generated in pairs.[1] The reversed process is that a pair of dislocations with opposite Burgers vectors can be annihilated inside the crystal. Here we report another phenomenon that elementary screw dislocations in SiC can turn into edge dislocations laying in the basal planes. Consequently, propagation of these dislocations along the [0001] direction can be stopped, resulting in screw dislocation-free regions.

Methods and Materials: Several longitudinally cut 4H-SiC wafers were imaged using synchrotron white-beam X-ray topography in the transmission geometry. The experiments were carried out at beamline X19C. We mainly used the symmetric 0004 reflection with the Bragg angle near 10 degrees. In this reflection, the elementary screw dislocations have strongest contrast on the topographs.

Results: A typical topograph showing the transformation of elementary screw dislocation into edge dislocations is shown in Fig. 1. In this figure, the black lines at the bottom (such as those marked by **S**) are images of elementary screw dislocations. These dislocations are slightly inclined against the vertical growth direction. It is clear that almost all of these dislocations "terminate" at the horizontal bands. Careful examination of this figure shows that the elementary screw dislocations actually do not terminate at the horizontal bands, but turn into horizontal dislocation segments (see the arrowed dislocation). Since the Burgers vectors are always along the vertical *c* direction, these horizontal dislocation segments are edge dislocations. Then, it is generally believed that the horizontal bands are images of high-density edge dislocations. A significant consequence of the dislocations' bending effect is that an almost screw dislocation-free region (**DF**) is formed in the upper part of the crystal. Further investigations about the mechanism underlying the bending effect will be carried out in our group, but it is apparent this effect can be utilized to significantly decrease the elementary screw dislocation density in SiC crystals.

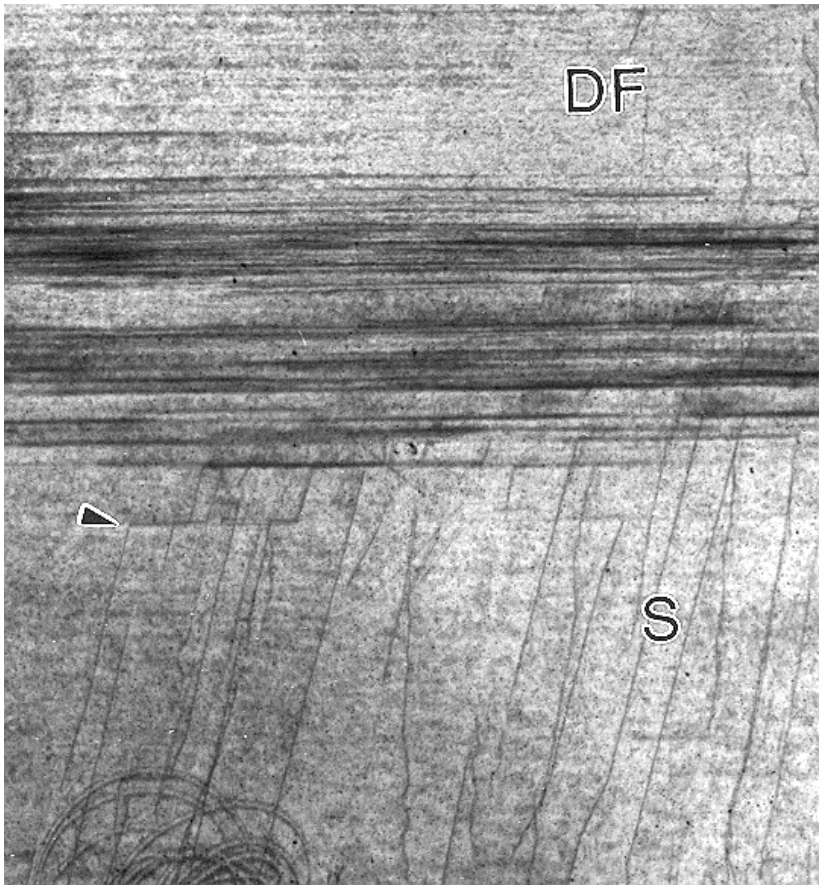

Figure 1. 0004 transmission synchrotron topograph showing the termination of elementary screw dislocations at basal plane barriers in longitudinally curt 4H-SiC single crystals.

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References: [1] M. Dudley, X. R. Huang, W. Huang, A. Powell, S. Wang, Neudeck, M. Skowronski, Appl. Phys. Lett. **75**, 784 (1999)